

Clarification to Technical Reviewers:

R004-E

Mobile Biodiesel Production Facility

Submitted by Energy & Environmental Research Center

Principal Investigators: David Dunham

Request for \$75,000; Total Project Costs \$150,000

1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Renewable Energy Council goals are: 1 – very unclear; 2 – unclear; 3 – clear; 4 – very clear; or 5 – exceptionally clear.

Reviewer 2A (Rating: 4)

The goal of this project is to make biodiesel from vegetable oil in a continuous-flow, bench-scale system with a capacity of up to 4 L/min. This is the primary stage in developing a fully portable system for making a biodiesel mix (80/20) on site. The ultimate purpose of this research is to examine the feasibility of developing continuous in-line flow ultrasonic biodiesel production. Secondary questions as provided by the investigators should also be mandatory for funding. These include:

- ☐ Can all of the system components be loaded onto a single trailer?
- ☐ What are the consumable requirements (water, catalyst, methanol...)?
- ☐ How will the power requirements of a portable biodiesel factory be met?
- ☐ Can the crushing process be scaled down as this idea requires?
- ☐ How will the waste products be handled?
- ☐ How will the 80–20 blend be produced on-site?
- ☐ What is an optimum production rate?
- ☐ Will the system need to operate 24/7?

Reviewer 2B (Rating: 4)

The goals and objectives of small scale biodiesel production does utilize North Dakota Grown Resources could add wealth for landowners and agricultural producers.

Reviewer 2C (Rating: 4)

The goal of this project is to make biodiesel from vegetable oil in a continuous-flow, bench-scale system with a capability of up to 4 L/min. Additionally, the biodiesel produced will be tested according to ASTM international standards. The proposed mobile biodiesel production facility could bring biodiesel production to where feedstocks are grown. The system will be capable of crushing feedstock seeds to obtain oil, combining that oil with alcohol and a base catalyst to form methyl esters and, finally, separating and washing the finished biodiesel in a continuous in-line processing system. This reviewer considers the objectives/goals of the proposed project are very clear.

2. With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable.

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Reviewer 2A (Rating: 4)

The research will be conducted from September 2009 to August 2010. This seems to be adequate time to accomplish the desired outcomes.

Reviewer 2B (Rating: 4)

The focus of this project it appears is to test ultrasonic equipment and how it aids in the transesterification process rather than to design a whole new system. That is achievable.

Reviewer 2C (Rating: 3)

The design of a system to convert biomass to biodiesel in a completely portable continuous inline biodiesel production facility will require the integration of three primary processes. The first process is the mechanical crushing of feedstock seeds to generate vegetable oil. The second process is the transesterification of oil with methanol under the influence of ultrasonic catalysis. The final process is the separation of the refined biodiesel from the glycerine by-product. Although each of these processes will require further development before system integration can take place, proof of transesterification using ultrasonic catalysis is the primary goal of this funding application. Specifically envisioned is the continuous-flow in-line production of biodiesel that meets ASTM D International 6751 standards at rates of up to 4 L/min. This reviewer believes that, with the approach suggested and time and budget available, the objectives are likely achievable.

3. The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.

Reviewer 2A (Rating: 2)

The proposed research is intriguing and could lead to the development of methods that can be applied to the agricultural community in North Dakota. The assembled team seems adequate to accomplish the goals and the EERC has a history of successful accomplishment of such projects. However, very little information was provided regarding the direct methodology that will be applied. I understand the basic work to be done involves buying a piece of equipment (A 1000-watt, 20-kHz ultrasonic processor and controlling equipment with capacity of 0.25–4 L/min.) and learning how to use it in this specific application. This, they can do.

PI Clarification: Since it is proposed that an ultrasonic processor would be an integral part of mobile biodiesel production, the testing of such a unit for this application is the main point of this research. This specific unit was identified because it had a large enough capacity range to be operated in both laboratory and demonstration settings. The PI envisions transesterification runs of varying lengths to test not only the quality of fuel produced but the reliability as well. Exact test parameters have not been finalized at this stage of the research process but could be submitted to NDREC prior to the start of formal experimentation.

Reviewer 2B (Rating: 2)

There is a lot of justification for why small scale biodiesel production should be pursued but there is very little in the proposal as to how or why ultrasonic stimulation would work, where or when it the process it would used, size of the ultrasonic equipment verses the size of the processing unit, etc.

PI Clarification: The proposal contained minimal direct information concerning the workings of ultrasonic catalysis technology because research and reports have already been published that address this issue and this literature was referenced in the report.

The ultrasonic catalysis equipment would be the main component in transesterification which was the second step of the overall process laid out in the author's proposal. In the transesterification step vegetable oil would be mixed in the ultrasonic reactor with a base/alcohol solution.

The small size of ultrasonic reactors – about 6 ft tall and covering a 2.5 ft² footprint for the unit proposed and capable of processing up to 1100 gpd – is one of the benefits of using this technology on a mobile platform. Certainly size would be a limiting factor of the system and much space would be required to hold mixing, cleaning, and storage tanks on a mobile unit.

Reviewer 2C (Rating: 4)

Bringing biodiesel production to where feedstocks are grown is not a new idea; however, the idea of an all-inclusive truck-mounted design that would travel to farms and produce fuel for onsite consumption is novel. Specifically envisioned in the proposal is a unit capable of crushing feedstock seeds to obtain oil, combining that oil with alcohol and a base catalyst to form methyl esters and, finally, separating and washing the finished biodiesel in a continuous in-line

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processing system. Several companies (Imerjent, Crystal Biofuels, Orbitek Inc.) currently offer small-scale, semiportable biodiesel production plants. Although these systems are portable, they are not designed for daily travel and do not have seed-crushing capabilities as the proposed project envisions.

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Renewable Energy Council goals will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant.

Reviewer 2A (Rating: 4)

This work can certainly assist in the biofuel development capacity within North Dakota (and other regions). North Dakota currently leads in the production of flax, sunflower, and canola. North Dakota is also increasing in the production of soybean. These crops can be used in the development of biodiesel. This research has strong implications for the state.

Reviewer 2B (Rating: 2)

I thank the authors for thinking creatively on this proposal. However, there are a lot of issues that small scale production biodiesel creates. There are serious quality issues in the biodiesel industry. The latest fuel quality survey conducted by the National Renewable Energy Laboratory shows that only 28% of the volume from small producers meets the ASTM D6751 specification. Most small producers do not test their product because the testing costs are prohibitive. Engine and vehicle manufacturers are absolutely against the idea of small scale production because of quality concerns and the impact it will have on their warranty liability. Small scale production creates very serious worker safety

concerns because the systems in place to safely handle methanol and the catalysts are generally not used.

PI Clarification: The PI understands the difficulties that accompany small scale biodiesel production, specifically fuel quality issues. The researcher does however feel that these problems are solvable and it is for this very reason that this research is proposed. A literary search done by the PI has shown that both large and small scale biodiesel producers can and have made biodiesel that is up to the ASTM D6751 standards. This work was referenced in the proposal. In addition, this project is proposed to discover whether or not ultrasonic catalysis can be used to produce ASTM standard biodiesel in a continuous flow system.

Certainly the testing issues that accompany small scale biodiesel productions are significant. However, the EERC does have a long track record of on-site environmental testing. The center has multiple mobile chemistry laboratories and much experience operating them in varying conditions. The PI believes that a small testing lab could be incorporated into a mobile processing unit to assure fuel quality. In addition the cost of ensuring biodiesel quality would have to be incorporated into the business plan of any endeavors.

The PI agrees with the safety concerns raised by the reviewer. Proper chemical safety training and operating procedures would be necessary for any operator of biodiesel processing equipment.

Reviewer 2C (Rating: 3)

As described in the previous item, bringing biodiesel production to where feedstocks are grown is not a new idea; however, the idea of an all-inclusive truck-mounted design that would travel to farms and produce fuel for onsite consumption is novel. Although the scientific and/or technical merits of the proposed research efforts are minimum (since they have been well-studied and well-known), the exploration for developing a mobile biodiesel production facility that could bring biodiesel production to where feedstocks are grown may be important, particularly for the State of North Dakota.

5. The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

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Reviewer 2A (Rating: 3)

Little research is available. Though the PI is an engineer, he holds only a BS degree, thus he is not well trained in the entire research process. There are others on the team who seem to have this experience.

PI Clarification: The reviewer's comments are correct as they pertain to the amount of research completed in the area of ultrasonic continuous flow processing of biodiesel. The PI however feels that this is an argument for such research to be undertaken. Even though there is not extensive literature currently available, enough work has been done previously to identify ultrasonics as a promising technology worthy of additional research.

Reviewer 2B (Rating: 3)

Reviewer 2C (Rating: 3)

To obtain biodiesel from feedstock seeds has been well-studied and well-known. The primary problem with producing smaller amounts of biodiesel, as would be required in a mobile biodiesel factory, is the time currently required for the transesterification process. This time-consuming process limits biodiesel production to large batches, requiring big mixing tanks and reaction times on the order of several hours. New technology utilizing ultrasonic mixing is currently becoming available, and manufacturers of this equipment claim it can reduce reaction time from hours to seconds, allowing biodiesel to be produced in continuous inline processing systems, yielding fuel that is 99% pure (ref. 3). The literature confirms these claims (refs. 4 & 5), but no information on pilot-scale or portable demonstration project results could be found. Multiple resources are available touting the advantages of using ultrasonic energy in the conversion of bio-oils to biodiesel in laboratory batch production (refs. 4–6). In contrast to this, minimal research has been undertaken in the area of continuous in-line flow ultrasonic biodiesel production. One study that was found indicated that an ultrasonic reactor system showed promise for continuous flow, industrial-scale biodiesel production but additional system design work would be required (ref. 7). This reviewer considers “the principal investigator’s awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal” is “adequate”.

6. The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 2A (Rating: 3)

The engineers involved in this project are adequate to complete this project.

Reviewer 2B (Rating: 3)

There is little information in the proposal regarding the researchers’ previous experience with ultrasonic technology or transesterification.

PI Clarification: The research team has not undertaken any research in the area of ultrasonic processing of biofuels due to this being a nascent technology.

Reviewer 2C (Rating: 3)

With a background in chemistry and mechanical engineering and work experience including bench-scale system design and operation, the principal investigator is suited to direct this project. The project team also includes investigators with backgrounds in mechanical, chemical, and electrical engineering. They will be called upon to provide expertise in the design, control, chemical process, and testing of the system. Therefore, this reviewer considers “the background of the investigator(s) as related to the proposed work” is “adequate”.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 2A (Rating: 4)

The plan and financial table provide adequate information for managing the project.

Reviewer 2B (Rating: 3)

Reviewer 2C (Rating: 3)

This reviewer considers “the project management plan, including a well-defined milestone chart, schedule, and financial plan” is “adequate”.

8. The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

Reviewer 2A (Rating: 5)

The heart of this project is dependent upon the purchasing of the equipment outlined in the proposal.

Reviewer 2B (Rating: 5)

For the scope of this project, the purchase of ultrasonic equipment is essential.

Reviewer 2C (Rating: 3)

There is a piece of equipment (an ultrasonic processing unit) requested to purchase with the price being \$17,000. The proposed purchase of this (and the only) equipment is “justified”.

9. The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

Reviewer 2A (Rating: 5)

The facilities available to the EERC to complete this work are exceptional. No better organization or facility in the state is available.

Reviewer 2B (Rating: 3)

EERC has a good reputation in biofuels research.

Reviewer 2C (Rating: 3)

All research work will be performed at the Energy & Environmental Research Center (EERC) in Grand Forks, North Dakota. One of the EERC centers of excellence is the National Alternative Fuels Laboratory (NAFL). Past and ongoing NAFL research has covered the areas of renewable ethanol, urea production, and aviation-grade ethanol and JP-8 fuels. The experience gained through development of these processes as well as the many other EERC fuel-related projects will be helpful in development of a mobile biodiesel production facility. The center also has laboratory space set aside for fuel-related research as well laboratory and testing equipment to verify the quality of the biodiesel that is produced. Therefore, this reviewer believes that “the facilities and equipment available and to be purchased for the proposed research” are “adequate”.

10. The proposed budget “value”¹ relative to the outlined work and the financial commitment from other sources is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)

Reviewer 2A (Rating: 5)

I have addressed this in my previous comments.

Reviewer 2B (Rating: 3)

Reviewer 2C (Rating: 4)

This reviewer believes that the idea of an all-inclusive truck-mounted design that would travel to farms and produce fuel for onsite consumption is novel and economically valuable, particularly for the State of North Dakota.

¹ “Value” – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.

10a. Financial commitment from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Higher priority is to be given if the application has private industry investment equal to or at least 50% or more of total cost.

The minimum 50% cash match is demonstrated.

Section C. Overall Comments and Recommendations:

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

Reviewer 2A (Fund)

Reviewer 2B (Do Not Fund)

I would not recommend that this project be funded. Rating Summary R004-E Page 7

There may be a role for the use of ultrasonic technology to assist in the transesterification process but to use it to promote small scale production should not be one of those roles.

Reviewer 2C (Funding May Be Considered)

The goal of this project is to make biodiesel from vegetable oil in a continuous-flow, bench-scale system with a capability of up to 4 L/min. Additionally, the biodiesel produced will be tested according to ASTM international standards. The proposed mobile biodiesel production facility could bring biodiesel production to where feedstocks are grown. The system will be capable of crushing feedstock seeds to obtain oil, combining that oil with alcohol and a base catalyst to form methyl esters and, finally, separating and washing the finished biodiesel in a continuous in-line processing system. Bringing biodiesel production to where feedstocks are grown is not a new idea; however, the idea of an all-inclusive truck-mounted design that would travel to farms and produce fuel for onsite consumption is novel and commercially valuable, particularly for the State of North Dakota. The team is qualified for the proposed research, and the proposed budget is adequate. Therefore, this reviewer’s overall recommendation of this proposal is “Funding May Be Considered”.